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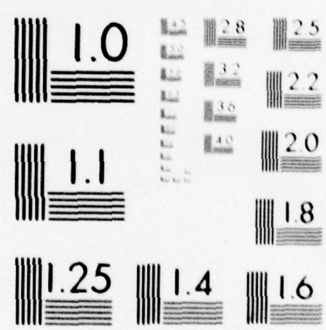

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DESTROYER ENGINEERED OPERATING CYCLE (DDEOC)

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System Maintenance Analysis
CG-26 CLASS
GUN FIRE CONTROL SYSTEMS
SWAB GROUP 481
SMA 1626-481
REVIEW OF EXPERIENCE

July 1979

Prepared for

Director, Escort and Cruiser
Ship Logistic Division
Naval Sea Systems Command
Washington, D.C. 20362
under Contract N00024-78-C-4062

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This report, the Review of Experience, documents the historical maintenance experience for CG-26 Class Gun Fire Control Systems, SWAB Group 481. It presents an analysis of the existing maintenance policy and recommends specific maintenance actions and maintenance policy modifications to improve system material condition. It has been developed for NAVSEA 931X, the manager of the Destroyer Engineered Operating Cycle (DDEOC) Program, under Navy Contract N00024-78-C-4062.

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(DDEOC)

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CG-26 CLASS
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J. C. Yancy, Jr.

ARINC Research Corporation
a Subsidiary of Aeronautical Radio, Inc.
2551 Riva Road
Annapolis, Maryland 21401

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FOREWORD

This report, the Review of Experience, documents the historical maintenance experience for CG-26 Class Gun Fire Control Systems, SWAB Group 481. It presents an analysis of the existing maintenance policy and recommends specific maintenance actions and maintenance policy modifications to improve system material condition. It has been developed for NAVSEA 931X, the manager of the Destroyer Engineered Operating Cycle (DDEOC) Program, under Navy Contract N00024-78-C-4062.

SUMMARY

The goal of the Destroyer Engineered Operating Cycle (DDEOC) Program is to effect an early improvement in the material condition of ships at an acceptable cost, while maintaining or increasing their operational availability during an extended operating cycle. In support of this goal, System Maintenance Analyses (SMAs) are being conducted for selected systems and subsystems of designated surface combatants. The principal element of an SMA is the Review of Experience (ROE). This report documents the ROE for the CG-26 Class Gun Fire Control Systems, SWAB Group 481.

The ROE is an analysis of the impact of historical maintenance requirements and policy on the operational performance or maintenance program of a ship system, and the significance of these requirements to the DDEOC Program. The report documents a recommended system maintenance policy and specific maintenance actions best suited to meeting DDEOC goals.

The ROE for the Gun Fire Control Systems included an analysis of all available maintenance data sources. The documented maintenance experience of the system was reviewed through analysis of data from the Maintenance Data System (MDS), Casualty Reports (CASREPs), and system overhaul records. Initial findings from these sources were correlated with Planned Maintenance System (PMS) requirements, the alterations program, and system technical manuals. Selected ships were surveyed and discussions were held with appropriate technical groups to validate identified maintenance requirements, to identify undocumented maintenance requirements, and to determine the status of current and planned actions affecting the Gun Fire Control Systems. All findings were evaluated and appropriate conclusions developed.

A recommended system maintenance policy was defined on the basis of these conclusions and recommendations were then made to implement the policy by periodically accomplishing specific types of corrective maintenance actions. These actions were documented for inclusion as tasks in the CG-26 Class Maintenance Plans. Also included, as appropriate, were recommendations for improving system preventive maintenance; integrated logistic support; reliability, maintainability, and availability; and depot- and IMA-level capabilities. Implementing these combined recommendations will minimize the impact of corrective maintenance on the extended operating cycle.

The major findings and conclusions of this ROE for the CG-16 and CG-26 Class Gun Fire Control Systems are summarized as follows:

- Electronic systems and components do not exhibit any regular failure pattern; that is, the probability of failure is the same at any given time. Therefore, no benefit is derived from periodic replacement of electronic components, and such replacement is not recommended.
- The existing maintenance strategy of performing the preventive maintenance prescribed by PMS and "run to failure" is adequate to support the AN/SPG-53A/F Radar Set and the Mk 47 Mod 9 Computer through an extended operating cycle.
- The Mk 68 Gun Fire Control Systems' equipments installed aboard CG-26 Class ships exhibit maintenance burden patterns similar to comparable equipments installed aboard DDG-37 and FF-1052 Class ships.
- Ship's force personnel, with very little outside assistance (IMA or depot), have the capability to perform most major maintenance actions to the AN/SPG-53A/F Radar Set and the Mk 47 Mod 9 Computer.

Reliable operation of the Gun Fire Control Systems can be expected throughout an extended operating cycle if the recommendations contained in this study are implemented and existing PMS maintenance requirements are strictly adhered to.

CONTENTS

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

System Maintenance Analyses (SMAs) are being conducted as part of the Destroyer Engineered Operating Cycle (DDEOC) Programs managed by NAVSEA 931X. The principal element of an SMA is the Review of Experience (ROE) of selected systems and subsystems of program-designated surface combatants. This report documents the ROE for the CG-26 Class Gun Fire Control System, SWAB Group 481, which was selected for analysis because equipments of this system have been major contributors to the CG-26 Class maintenance burden.

1.2 PURPOSE AND SCOPE

The ROE is an analysis of the impact of historical maintenance requirements and policy on a ship system's operational performance or maintenance program. It serves as a vehicle for documenting the significance of historical maintenance requirements to the DDEOC Program.

The objective of the ROE is to define and document a maintenance program for CG-26 Class ships that will prevent or reduce the need for unscheduled maintenance while improving material condition and maintaining or increasing ship availability throughout an extended ship operating cycle. The maintenance program defined and documented in an ROE for a selected equipment will be the basis for maintenance tasks to be developed for inclusion in the Class Maintenance Plan.

The analysis documented in this report is specifically applicable to the Gun Fire Control Systems, SWAB Group 481, of the CG-26 Class ships. This analysis utilized all available documented data sources from which system maintenance experience could be identified and studied. These included Maintenance Data System (MDS) data, Casualty Reports (CASREPs), Board of Inspection and Survey (INSURV) reports, departure reports, Ship's Alteration and Repair Packages (SARPs), Planned Maintenance System (PMS) requirements data, system alteration documentation, and system technical manuals. Sources of undocumented data used in this analysis included discussions with ship's force and cognizant Navy technical personnel.

1.3 REPORT FORMAT

The remaining chapters of this report describe the analysis approach (Chapter Two), briefly present the significant system maintenance experience and discuss essential maintenance requirements (Chapter Three), and summarize the conclusions and recommendations derived from the analysis (Chapter Four). Specific analyses, evaluations, and data compilations that support the findings of this effort are included, as necessary, in appendixes.

CHAPTER TWO

APPROACH

2.1 OVERVIEW

This chapter describes the approach followed in performing the ROE for equipments and subsystems in the Gun Fire Control Systems, SWAB Group 481. These systems were identified for analysis in the *DDEOC Selected Items for Analysis List, CG-26 Class*, ARINC Research Publication 1653-06-TR-1875. Primary data sources were identified in Section 1.2. The data were used to identify, define, and analyze maintenance requirements that have significantly affected the system's operational availability and material condition. A recommended maintenance strategy and implementation procedures were formulated on the basis of analysis results. The major steps of the analysis were as follows:

- Relevant documented and undocumented maintenance history data were compiled for the selected equipments or subsystems.
- These data were analyzed to identify and define recurring maintenance requirements that have a significant impact on the operational availability and material condition of these equipments or subsystems.
- The results of ROE analyses were compared with results of previously completed analyses of identical or functionally similar equipment or subsystems (on other classes of ships) to determine if prior maintenance strategy and implementation recommendations apply to CG-26 Class ships.
- If previously developed maintenance strategies and recommendations were determined to be applicable to similar equipment or subsystems of the CG-26 Class ships, they were identified and documented in the report. CMP tasks previously developed were modified to reflect their applicability to this ship class.
- Where previously developed maintenance strategies and implementation recommendations were not applicable to CG-26 Class ships, a detailed maintenance analysis was conducted to develop the maintenance strategy to be recommended and the steps to be employed in implementing that strategy.

2.2 DATA COMPILATION

The analysis began with the compilation of comprehensive data on the maintenance history of the system. The data file assembled consisted of four key elements: an MDS data bank, a CASREP narrative summary, a system overhaul experience summary, and a system ShipAlt summary. A library of appropriate technical manuals, bulletins, and related documents was also assembled. The MDS data bank was compiled by examining all MDS data reported for the CG-16 and CG-26 Classes from 1 January 1970 through 31 December 1977. In the case of the CG-16 Class, MDS data reported between 1 January 1970 and completion of modernization were not considered. Thus the data bank for ships of this class includes only the MDS reported maintenance actions occurring between the end of modernization and 31 December 1977. CASREP information was obtained by reviewing CASREPs submitted against the various Gun Fire Control Systems' equipments during the data period 1 January 1972 through 31 August 1978. Overhaul information was obtained from authorized SARPs and departure reports for ships of both classes.

2.3 MAINTENANCE DATA ANALYSIS

Recurring maintenance requirements affecting the availability and material condition of subsystems or equipments were identified by screening data obtained from the above-described sources, as well as from ship surveys, discussions with Navy technical personnel, and NAVSEA special-interest programs.

MDS data provided the initial and primary source of information screened. The resulting data base includes all part and labor records, as well as narrative material, describing maintenance actions reported against system components. The purpose of the screening process was to identify maintenance actions that had been reported against the Gun Fire Control Systems' equipments.

Preliminary analysis of each of the equipments was directed toward determining the historical maintenance profile in terms of reported manhours per equipment operating year, types of maintenance actions commonly recurring, type and number of repair parts used, CASREP frequency, and past ROH experience. The historical maintenance profile was then compared with similar information developed for identical or functionally similar subsystems or equipments previously subjected to detailed analysis during the performance of ROEs for FF-1052 and DDG-37 Class ships. Further analysis was not conducted where the results of this comparison showed that the maintenance profile for the CG-26 Class equipment was essentially the same as that of an identical or functionally similar subsystem or equipment previously analyzed on another ship class. Instead, the maintenance strategy and implementation recommendations developed for the same or similar equipment on a previously analyzed ship class were identified as being applicable to the CG-26 Class ships, as documented in this report.

Where the results of the historical maintenance profile comparison did not reveal a marked similarity, a detailed maintenance requirements engineering analysis was conducted. Initially, man-hour and parts-usage trends were examined to determine if either parameter increased as a function of time after overhaul, indicating wear-out or deterioration. If no increasing trend was evident, it was assumed that the equipment or subsystem could be expected to continue to operate satisfactorily, exhibiting its current maintenance characteristics throughout an extended operating cycle. If an increasing trend was evident, additional analysis was conducted to identify apparent problems and establish the time at which planned restorative maintenance would be required to prevent an unacceptable increase in maintenance burden and downtime.

Detailed analysis was directed toward defining each recurring significant maintenance requirement in terms of several specific factors: the effect of the maintenance action on the subsystem or equipment, the interval between occurrences of the action, the redundancy of the affected subsystem or equipment, the criticality to mission accomplishment, the resources required to perform the necessary corrective maintenance, and the expected subsystem or equipment downtime.

Once the factors associated with the historically required maintenance actions were identified, the individual types of historical maintenance actions were analyzed to identify any design- or maintenance-related problems that would have an impact on the selection of a maintenance strategy. Solutions were then sought by examining each problem in relation to the extent to which it was recognized and its amenability to established types of corrective action. These analysis criteria are expressed in the following questions:

- Is the problem known to the Navy technical community, and has a solution been proposed or established?
- Will a design change reduce or eliminate the problem?
- Is the problem PMS-related? Can it be reduced or eliminated by changes to PMS? (These changes might include adding or deleting requirements, changing periodicity, or developing material condition assessment tests and procedures.)
- Can the problem be reduced or eliminated by improving the system's integrated logistic support (ILS) at the ship's force level?
- Can the problem be reduced or eliminated by improving Intermediate Maintenance Activity- (IMA) or depot-level capabilities?
- Can this problem be reduced or eliminated by revising the existing maintenance strategy?

An affirmative answer to any question resulted in analysis of the effects of the solution and in an estimate, when possible, of the cost to implement the solution. A negative answer prompted the engineer to go to the next question. After all the questions concerning an individual problem were asked, the alternative solutions were evaluated and the most

acceptable alternatives defined and documented as recommendations. These recommended solutions to identified design or maintenance-related problems were then considered during the definition of the maintenance strategy. A further series of implementation recommendations was then formulated to accomplish the objectives of the maintenance strategy selected for the engineered operating cycle (EOC).

2.4 MAINTENANCE PROGRAM DEFINITION

The recommended maintenance program stems directly from the subsystem and equipment maintenance strategies identified by the analysis. The total maintenance program includes both the scheduled and unscheduled preventive maintenance and "engineered" and "qualified" corrective maintenance required to maintain the subsystems and equipments at acceptable levels of material condition and availability over an extended operating cycle. Engineered corrective maintenance comprises those tasks which are well defined and must be accomplished periodically. Qualified tasks are those nonspecific repairs that are likely to be required but cannot be characterized precisely as to nature and frequency.

In development of the implementation recommendations, the results of the analysis were used to identify specific corrective maintenance tasks that would be required periodically. Once these tasks were identified, the frequency of accomplishment, the manpower resources required for accomplishment, and the maintenance level required to perform the work were determined for engineered tasks. Qualified maintenance tasks were also identified on the basis of historical data to reserve blocks of man-hours at specified intervals to complete required but nonspecific Class C repairs on the subsystems or equipments under analysis.

Where appropriate, additional recommendations were developed for improving subsystem or equipment reliability, availability, and maintainability; logistic support; and IMA- or depot-level capabilities.

The steps described in this section effectively define the maintenance program recommended for the subsystems and equipments identified for detailed analysis in this ROE. Recommendations resulting from this analysis will be used to develop the Class Maintenance Plan (CMP).

CHAPTER THREE

RESULTS

3.1 OVERVIEW

This chapter presents the results of a System Maintenance Analysis of selected equipments of the CG-26 Class Gun Fire Control Systems (GFCS) [Ship Work Authorization Boundary (SWAB) 481]. Appendix A provides a block diagram showing the basic component relationships for this SWAB. Subsections of the chapter describe system functions and component relationships, present the selection criteria for SWAB component analysis, and identify maintenance strategies for the system and components that will reduce or eliminate maintenance problems and related equipment failures having the greatest impact on the system maintenance burden.

CG-26 Class ships were visited to confirm the results of the analysis or to identify other problems that did not manifest themselves in the analysis of the maintenance data.

Four SWAB 481 equipments were selected for analysis: AN/SPG-53A Radar, Mk 1 Mod 1 Radar Signal Processing Equipment (RSPE), Mk 47 Mod 9 Computer, and Mk 116 Mod 4 Computer. These equipments were selected from the *Selected Items for Analysis Lists, CG-16 and CG-26 Classes* (ARINC Research Publication 1653-06-TR-1875 dated February 1979) on the basis of their respective contributions to the total class maintenance burden as determined by their individual Maintenance Burden Factor (MBF) rankings. Three categories of information were used to determine this ranking: (1) the ship's force and Intermediate Maintenance Activity (IMA) corrective maintenance man-hour burden (MBF_{cm}) reported in the Maintenance Data System (MDS), (2) the annual Planned Maintenance System (PMS) man-hour burden (MBF_{pm}) as determined from equipment Maintenance Requirement Cards (MRCs), and (3) the average number of man-days required for equipment repair during Regular Overhaul (ROH) as reported in Class Repair Profiles. A summary of these data for the selected (GFCS) equipments is presented in Table 3-1, together with relative corrective and preventive maintenance burden rankings. SWAB 481 equipments did not meet the criteria for inclusion on the CG-16 Class, Selected Items for Analysis List; therefore, no CG-16 Class SWAB 481 analysis or recommendations are provided in this report.

The major GFCS components installed aboard the CG-26 Class ships are common or similar to major GFCS components installed aboard the DDG-37 Class and the FF-1052 Class ships. Components that are not common to all

Table 3-1. CG-26 CLASS MAINTENANCE BURDEN FIGURE SUMMARY

SWAB Number	CM Burden Rank Within Ship	PM Burden Rank Within Ship	Selected Equipment†	Applicable APLs	Class Population	*MBF_{CM} (Man-hours)	**MBF_{PM} (Man-hours)	ROH Burden (M-D) (Man-days)
481-1	9	3	AN/SPG-53A Radar	56995306 78640190SA	9 7	2780	12,317	407
481-1			Mk 1 Mod 1 RSPE	78640113	9	517		
481-1			Mk 47 Mod 9 Computer	49402033	9	1696	17,084	
481-1			Mk 116 Mod 4 Computer	49402034	9			
481-1	–	–	Mk 68 Mod 3 Gun Director	49401956 49402515 49401999 49401988 49401989 49402731	9	1894	4,366	138
481-1	–	–	Mk 16 Mod 2 Stable Element	49402030 49402030FA 49402030FB	9	312	2,250	54

*This column presents the combined average reported Ship's Force and IMA corrective maintenance man-hours expended on a particular equipment per year for the entire class population of that equipment.

**This column presents the total required annual PMS man-hours, as reflected by appropriate MRCs for the entire class population of that equipment.

†Data for the Mk 51 Mod 3 Gun Directors not shown because of their planned removal during BOH.

three ship classes usually differ only in modification (Mod) number. In all cases of similar components in the three classes, the FF-1052 Class carries the newest Mod and the DDG-37 Class carries the oldest Mod.

The MDS component burdens were compared initially by using the information presented in the MDS Summary of Selected SWAB 481 Components (see Appendix B). The comparison results are presented by ship class in Table 3-2. This comparison showed that the same components identified on the Selected Items for Analysis List for the CG-26 Class (AN/SPG-53A Radar, Mk 47 Computer, and Mk 1 Mod 1 RSPE) accounted, respectively, for 65.2 percent, 63.1 percent, and 59.8 percent of the GFCS ship's force man-hour burden for the CG-26 Class, DDG-37 Class, and FF-1052 Class. Components in the CG-26 Class generally reflected a higher average man-hour component burden per ship operating year than their counterparts on the other two classes; however, the CG-26 Class components exhibited maintenance burden patterns similar to those of comparable components of the other classes of ships. More detailed component comparisons are presented in the appropriate component subsections.

Each component identified by the Selected Items for Analysis List for the CG-26 Class is discussed in a subsequent section.

3.2 GUN FIRE CONTROL SYSTEM, SWAB 481-1

The primary purpose of the GFCS installed aboard a CG-26 Class ship is to provide gun orders to the ship's 3-inch, 50-caliber gun mounts or the ship's 5-inch, 54-caliber gun mounts (or both) during air and surface engagements. The system may also be utilized as a secondary target-designation source by other components of the ship's weapons system, and as an aid to the ship's underwater battery fire control system (UBFCS). The major components of SWAB 481 are shown in Table 3-3. The individual component functions are discussed in appropriate component subsections.

The component group that collectively provides gun orders to the 5-inch, 54-caliber gun mounts is commonly called the Mk 68 GFCS. As shown in Table 3-3, all CG-26 Class ships have a Mk 68 GFCS with a 5-inch, 54-caliber gun mount and two 3-inch, 50-caliber mounts.

Baseline Overhaul (BOH) will modify the present GFCS configuration by removing the 3-inch, 50-caliber gun mounts and the associated fire control components from the CG-26 Class ships (see Table 3-3, 3" Guns). For this reason, the 3-inch, 50-caliber gun mount and its fire control components were not analyzed.

The Mk 68 Mod 8 GFCS will be modified to a Mk 68 Mod 16 GFCS during BOH on six of the nine CG-26 Class ships (CG-26, -27, -28, -30, -32, and -33). The remaining three CG-26 Class ships will be modified to the Mk 68 Mod 16 during the first Regular Overhaul (ROH) after BOH (CG-29, -31, and -34). Table 3-4 shows the major component changes that will take place with the installation of the Mk 68 Mod 16 GFCS. The effect of these modifications will be discussed in the applicable component subsections.

Table 3-2. COMPARISON OF SELECTED Mk 68 GFCS COMPONENTS FOR THE CG-26 CLASS, DDG-37 CLASS, and FF-1052 CLASS

Nomenclature	Percent of Total Ship's Force Man-Hours	Percent of Total IMA Man-Hours	Percent of Total System Man-Hours	Percent of Total System Parts Cost	Average Man-Hours Per Ship Operating Year
CG-26 Class					
AN/SPG-53A Radar	36.4	20.3	35.2	43.4	302.3
Mk 47 Mod 9 Computer	21.9	10.1	21.1	27.6	181.3
Mk 68 Mod 3 Gun Director	12.6	38.7	14.6	4.6	125.6
Mk 2 Mod 3 Director Control Drive	7.0	5.4	6.9	4.6	59.4
Mk 1 Mod 1 RSPE	6.9	2.4	6.5	1.9	56.2
Mk 16 Mod 2 Stable Element	4.3	.8	4.0	8.1	34.7
Mk 75 Mod 1 Range-finder	2.1	4.6	2.3	.9	19.4
Total	91.2	82.3	90.6	91.1	
DDG-37 Class*					
AN/SPG-53A Radar	32.4	6.8	30.2	50.8	221.7
Mk 47 Mod 7 Computer	24.9	7.3	23.4	26.4	171.7
Mk 68 Mod 2 Gun Director	9.2	20.6	10.2	3.2	74.5
Mk 16 Mod 1 Stable Element	10.0	3.9	9.5	9.6	69.7
Mk 2 Mod 2 Director Control Drive	5.6	9.9	5.9	1.5	43.8
Mk 1 Mod 1 RSPE	5.8	.7	5.4	3.7	39.5
Mk 41 Mod 10 Range-finder	.08	38.7	3.3	.04	201.5
Total	87.9	87.9	87.9	95.2	
FF-1052 Class**					
AN/SPG-53A Radar	39.8	11.6	37.9	49.1	160.6
Mk 47 Mod 10/11 Computer	14.6	10.5	14.3	14.7	60.7
Mk 68 Mod 3 Director	12.9	29.5	14.1	2.8	59.9
Mk 16 Mod 2 Stable Element	5.0	1.2	4.8	9.7	20.1
Mk 2 Mod 3 Director Control Drive	5.6	10.1	4.9	11.4	25.2
Mk 1 Mod 1 RSPE	5.4	0	4.0	0.9	21.3
Mk 75 Rangefinder	1.6	14.2	2.5	1.6	10.4
Total	84.9	77.1	82.5	90.2	

*Data from Table 3-1 of *System Maintenance Analysis, DDG-37 Class Mk 68 Gun Fire Control System*, ARINC Research Publication 1652-03-26-1807, September 1978.

**Data from Table 3-1 of *System Maintenance Analysis, FF-1052 Class Mk 68 Gun Fire Control System*, ARINC Research Publication 1646-03-4-1585, March 1977.

Table 3-3. CG-26 CLASS SWAB 481 MAJOR COMPONENTS		
Nomenclature	Components per Ship	Gun System
AN/SPG-53A/F Radar Set	1	5"
Mk 47 Mod 9 Computer	1	5"
Mk 116 Mod 4 Ballistic Computer	1	5"
Mk 68 Mod 3 Gun Director	1	5"
Mk 16 Mod 2 Stable Element	1	5"
Mk 2 Mod 3 Dynamic Tester	1	5"
Mk 7 Mod 1 Error Recorder	1	5"
Mk 14 Mods 5/8 F.C. Switchboard	1	5"
Mk 32 Mod 2 Relay Transmitter	1	3"
Mk 51 Mod 3 Gun Director	2	3"

Table 3-4. MOD 16 CONFIGURATION CHANGES		
Major Components	Mk 68 Mod 8/All (Present)	Mk 68 Mod 16 (BOH/Subsequent ROH)
Radar Set	AN/SPG-53A	AN/SPG-53F
Computer	Mk 47 Mod 9	Mk 160 Mod 1
Director	Mk 68 Mod 3	Mk 68 Mod 9
Stable Element	Mk 16 Mod 2	Mk 16 Mod 11
Dynamic Tester	Mk 2 Mod 3	--
Error Recorder	Mk 7 Mod 0/1	Mk 12 Mod 1
Switchboard	Mk 14 Mod 8	Mk 14 Mod 18

For this analysis, the Mk 1 Mod 1 RSPE and the AN/SPG-53A Radar (Subsection 3.2.1) will be discussed as one component because of their close functional relationship, as will be the Mk 47 Mod 9 Computer and the Mk 116 Mod 4 Ballistic Computer (Subsection 3.2.2). The AN/SPG-53A Radar Set and the Mk 47 Mod 9 Computer are discussed in subsequent subsections because they appear on the CG-26 Class Selected Items for Analysis List and they collectively account for 65.2 percent of the CG-26 Class Mk 68 GFCS ship's force man-hours over the MDS data period observed (see Table 3-2).

A detailed comparative analysis, and maintenance analysis with appropriate recommendations for each component analyzed, follows.

3.2.1 AN/SPG-53A Radar Set (APL 56995306) and Mk 1 Mod 1 Radar Signal Processing Equipment (APL 78640113)

3.2.1.1 Background

The Mk 68 GFCS directs the aiming and firing of the 5-inch, 54-caliber gun by using information supplied by the AN/SPG-53A Radar Set, the Mk 68 Gun Director, and the Mk 47 Computer. The primary purpose of the Radar Set is to supply range data to the computer, and bearing and elevation error voltages to the Mk 76 Amplifier (a subcomponent of the Mk 68 Gun Director). This information is ultimately combined with other shipboard data to produce orders that position the gun mount.

The radar set consists of the following eleven major units (Units 11 and 12 are not intrinsic to the radar):

Unit Number	Description
1	Antenna Assembly
2	Motor Assembly
3	Receiver-Transmitter
4	Power Supply Group
5	High Voltage Power Supply
6	Console, Radar Set
7	Foot Switch
9	Control Amplifier
10	Foot Switch
11	Blower
12	Radar Signal Processing Equipment (RSPE) (APL 78650113)

OrdAlt 4480, which added the RSPE to the AN/SPG-53A Radar Set, provides the Radar Set with a rapid automatic range and angle acquisition facility and significantly improves the radar performance in a jamming or countermeasures environment.

The AN/SPG-53A Radar Set is scheduled for modification to an AN/SPG-53F (APL 56995320) Radar Set before or during BOH. At the present time, the AN/SPG-53F Radar Set is installed on eight of the nine CG-26 Class ships; by FY 1980 it will be installed on CG-34.

Installation of ShipAlt CG-26-0442K -- with block OrdAlt 8709, consisting of OrdAlts 6894, 6973, 7672, and 8192 -- converts the AN/SPG-53A Radar to the AN/SPG-53F Radar. This ShipAlt is designed to increase the maintainability and reliability of Unit 6 by replacing one subunit and adding two new subunits. Table 3-5 shows specific differences resulting from installation of ShipAlt CG-26-0442K.

OrdAlt Number	Description	Unit/ Subunit
8709	OrdAlts 6894, 6973, 7672 and 8192	6
6894	Replaces Range Computer CP-449/SPG-53A with digital Range Computer Mk 154 Mod 0	6A
6973	Provides radar with a target signal generator	6E
7672	Provides radar with an angle error indicator	6D
8192	Installs fan in Unit 6G	6G
--	Installs Ready Spares Cabinet Mk 6 Mod 0	

Table 3-5. SHIPALT CG-26-0442K

With the exceptions noted above, the AN/SPG-53F Radar Set will basically comprise the same parts and perform the same functions as the AN/SPG-53A Radar Set. Therefore, the unchanged units in the AN/SPG-53F Radar Set are expected to show maintenance patterns very similar to those previously experienced with the AN/SPG-53A Radar Set.

In addition to the AN/SPG-53F modification, the installation of the Mk 68 Mod 16 GFCS will remove the RSPE (Unit 12) and replace it with a solid-state video processor. The video processor will perform the same function as the RSPE, but it will be installed as an integral part of Unit 6, the radar set console (OrdAlt 8949-WO213, GFCS Mk 68 Baseline 1E).

Fleet personnel and maintenance school instructors report that corrective maintenance time is greatly reduced and alignments of the equipment are easier and less time-consuming with this OrdAlt installed because the video processor is solid-state and physically part of the radar set. Previously, the RSPE was seated in the gun director.

The other significant change to the radar set during the Mk 68 Mod 16 installation will be the removal of the AS-515 Scanner Assembly (Subunit 1A) and the installation of the Mk 38 Electronic Scanner (OrdAlt 6920, modified by OrdAlt 9214).

Although the AN/SPG-53F Radar Set will be installed on all CG-26 Class ships before or during BOH, only those ships with the Mk 68 Mod 16 GFCS installed are scheduled to receive the solid-state video processor and the Mk 38 Electronic Scanner Assembly. NAVSEA 0432 technical personnel disclosed that all AS-515 Scanner Assemblies will eventually be replaced by Mk 38 Electronic Scanners through normal attrition. The new scanner assembly is expected to be easier to maintain and to require fewer corrective maintenance man-hours than the AS-515 Scanner Assemblies. For this analysis, it is assumed that the new Mk 38 Electronic Scanners will not be available during BOH to those CG-26 Class Ships which will retain their present GFCS configuration until a subsequent ROH. Therefore, recommendations made in this subsection are categorized as (1) CG-26 Class ships

receiving the Mk 68 Mod 16 GFCS during BOH (CG-26, -27, -28, -30, -32, and -33); (2) CG-26 Class ships receiving the Mk 68 Mod 16 GFCS during a subsequent ROH (CG-29, -31, and -34); or (3) all CG-26 Class ships.

3.2.1.2 Comparative Analysis

This subsection compares and contrasts the maintenance experience of the CG-26 Class AN/SPG-53A Radar Sets (including the Mk 1 Mod 1 RSPE) with that of similar radar sets installed aboard DDG-37 Class and FF-1052 Class ships by comparing the reported MDS man-hour burdens for the AN/SPG-53A Radar Sets, the reported parts usage data on the radar sets, and the CASREP rate and cause for radar sets of the three ship classes. If these three parameters are similar among the ship classes compared, the maintenance experience of the CG-26 Class AN/SPG-53A Radar Sets can be considered similar to that of the DDG-37 Class and FF-1052 Class AN/SPG-53A Radar Sets. Apparent differences in any one of these parameters will be examined in the following subsections.

MDS Man-Hour Burden Comparison

An initial comparison of the reported MDS data on the Mk 68 GFCS among three ship classes showed that the AN/SPG-53A Radar Set (including the Mk 1 Mod 1 RSPE) was responsible for 38.2 percent to 45.2 percent of the system ship's force man-hours. This system-level comparison also showed that the CG-26 Class AN/SPG-53A Radar Sets were responsible for a significantly greater proportion of the system's IMA man-hours than the DDG-37 Class and the FF-1052 Class radar sets (see Table 3-2).

Further comparisons of the average number of reported ship's force man-hours and IMA man-hours reported per ship operating year for the radar sets and RSPE showed that the CG-26 Class reported a significantly greater number of both ship's force man-hours and IMA man-hours per ship operating year than either the DDG-37 Class or the FF-1052 Class ships, as shown in Table 3-6. Table 3-6 also shows that the CG-26 Class ships have experienced a greater number of average ship operating years than the other two ship classes examined. These data indicate that either CG-26 Class ships are performing more radar set corrective maintenance on a regular basis than the other ship classes or equipment deterioration is increasing as time out of overhaul is increasing, necessitating more corrective maintenance as a function of time. These possibilities and the reasons for the greater CG-26 Class corrective maintenance man-hour burdens are examined in Subsections 3.2.1.4 and 3.2.1.5.

Parts Usage Comparison

Parts usage for the AN/SPG-53A Radar Set and Mk 1 Mod 1 RSPE was compared by using only those parts considered to be significant in terms of their ratio of replacements to total part population, or their individual cost. Appendix C summarizes the significant parts used for the AN/SPG-53A Radar Set and the Mk 1 Mod RSPE installed aboard CG-26 Class ships during the MDS data period. This appendix also identifies the subunit or circuit use most often reported through the MDS narratives for each significant part.

Table 3-6. MDS MAN-HOUR COMPARISON OF THE AN/SPG-53A RADAR SET (INCLUDES MK 1 MOD 1 RSPE) FOR CG-26, DDG-37, AND FF-1052 CLASS SHIP

Ship Class	Average Ship Operating Years per Ship	Ship's Force Man-Hours / Total Class Ship Operating Years	IMA Man-Hours / Total Class Ship Operating Years	Total Man-Hours / Total Class Ship Operating Years
*CG-16	6.7	343.5	14.9	358.4
**DDG-37	4.8	256.5	4.6	261.1
†FF-1052	3.4	178.6	3.4	182.0

*Data derived from Appendix B.

**Data derived from *System Maintenance Analysis for DDG-37 Class Mk 68 Gun Fire Control System*, September 1978.

†Data derived from *System Maintenance Analysis for FF-1052 Class Mk 68 Gun Fire Control System*, March 1977.

When significant parts of the CG-26 Class radar sets and the RSPE were compared with parts identified as significant for the DDG-37 Class and the FF-1052 Class ships, it was found that approximately 36 percent of the CG-26 Class AN/SPG-53A Radar Set parts had been previously identified during both the DDG-37 Class and the FF-1052 Class GFCS analyses. Approximately 78 percent of the CG-26 Class RSPE significant parts were also identified in the DDG-37 Class GFCS analysis (see Appendix C).

The Radar Set and RSPE significant parts were also examined to determine which of the 11 major units most often required repair. It was assumed that a part replacement indicated a repair action. Table 3-7 summarizes the repairs to the major units of the radar and the RSPE for CG-26 Class ships.

For the CG-26 Class and the DDG-37 Class ships, units 3 and 6 collectively accounted for approximately 63.2 percent and 62.8 percent, respectively, of the significant parts repairs. Although a different method was used to define radar unit repairs in the FF-1052 Class GFCS analysis, units 3 and 6 accounted for 66.6 percent of the radar set repairs for the FF-1052 Class (data from Table 3-2 of the FF-1052 Class Mk 68 GFCS SMA).

These parts usage data indicate similar corrective maintenance experience for the three ship classes examined.

Table 3-7. AN/SPG-53A UNIT REPAIRS

Unit Number	Unit Nomenclature	DDG-37 Class*		CG-26 Class	
		Number of Repairs	Rank	Number of Repairs	Rank
1	Antenna Assembly	68	7	46	7
3	Receiver-Transmitter	1594	2	1231	2
4	Power Supply Group	1096	3	720	3
5	High Voltage Power Supply	515	4	287	6
6	Console - Radar Set	1655	1	1707	1
9	Control Amplifier	126	5	288	5
11	Blower	0		3	8
12	Radar Signal Processing Equipment	88	6	394	4
	Unit Total	5142		4676	

*Data from Table 3-3 of the DDG-37 Class Mk 68 Gun Fire Control System SMA.

CASREP Comparison

CASREPs for the AN/SPG-53A Radar Set and the Mk 1 Mod 1 RSPE were compared by ship class to determine if the types of critical failures experienced by the radar were similar on the different classes of ships. Table 3-8 summarizes the available CASREP data on the CG-26 Class, DDG-37 Class, and FF-1052 Class ships.

Table 3-8. CASREP SUMMARY AN/SPS-53A RADAR AND MK 1 MOD 1 RSPE

Unit/Component	Subunit Use	CASREPs Reported CG-26 Class			CASREPs Reported DDG-37 Class		CASREPs Reported FF-1052 Class	
		No. of Ships Reported	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
1. Unit 1 Radar Antenna								
(a) Scanner	1A	6	8		10		43	
(b) Feedhorn	1A	2	2		0		7	
(c) Reference Generator	1A	0	0		1		9	
(d) Control Electronic Assembly	1A	0	0		0		5	
Subtotal			10	14.5	11	17.2	64	34.0
2. Unit 3 Receiver-Transmitter								
(a) Magnetron	3D	6	7		6		11	
(b) AFC Unit	3H	3	5		3		19	
(c) Keyer Driver	3B	2	2		0		0	
(d) High Voltage Box	3B	2	2		3		4	
(e) Local Oscillator	3F	2	2		4		1	
(f) I.F. Preamplifier	3J	2	2		0		0	
(g) Flexible Waveguide	3E	2	2		0		4	
(h) T-R Tube	3E	1	1		0		4	
(i) Crystals	3G	0	0		1		3	
(j) Pulse Modulator	3B	1	1		0		0	
(k) Other	Unknown	1	1		7		0	
Subtotal			25	36.2	25	39.1	53	28.2
3. Unit 4 Power Supply Group								
(a) Transformer	Unknown	1	1		0		3	
(b) Other	Unknown	1	1		0		0	
Subtotal			2	2.9			3	1.6
4. Unit 5 High Voltage Power Supply								
(a) Power Supply	5B	2	4		7		7	
(b) Thyratron	5A	1	1		0		0	
(c) Thyratron	5C	1	1		2		2	
(d) Other	Unknown	1	1		0		0	
Subtotal			7	10.1	9	14.1	9	4.8
5. Unit 6 Console, Radar Set								
(a) Range Gear Unit	6G	2	4		1		4	
(b) Transducer	6G	3	3		1		0	
(c) Synchro	6G	1	1		0		0	
(d) Synchronizer	6A	1	1		0		2	
(e) Potentiometer	6B	1	1		0		0	
(f) Transformer	6B	1	1		0		0	
(g) Coil (Radar Receiver)	6F	1	1		0		0	
(h) Relay	6G	0	0		0		2	
(i) Range Computer	6G	0	0		0		19	
(j) Radar Receiver	6F	0	0		0		3	
(k) Tubes	6G	1	1		0		0	
Subtotal			13	18.8	2	3.1	30	15.9
6. Waveguide	Unknown	1	1	1.4	3	4.7	9	4.8
7. Other	Unknown	1	1	1.4	6	9.4	6	3.2
8. Unit 12 Radar Signal Processing Equipment	12/12A	6	10	14.5	8	12.5	14	7.4
Total			69	99.8	64	100.0	188	99.9
Number of ships in class		9			9		46	
CASREP data period		1/1/72 - 9/1/78			7/1/73 - 9/30/77		1/1/73 - 6/30/76	
Class Ship Operating Years (SOY) during data period		53.0 SOY			43.9 SOY		143.8 SOY	
Average Ship Operating Years per Ship		5.9			4.8		3.1	
CASREPs per Ship Operating Year		1.3			1.5		1.3	

The CG-26 Class failure experience is similar to that of the DDG-37 Class and the FF-1052 Class ships. The rates of CASREP submissions against the radars for the three classes of ships examined were nearly the same, as shown in Table 3-8. These CASREPs-per-ship-operating-year figures were determined by dividing the class CASREP total by the total class ship operating years during the data period.

CG-26 Class radar set units 3 and 6 were responsible for approximately 55 percent of the total radar set CASREPs, while the DDG-37 Class and the FF-1052 Class radar set units 3 and 6 accounted for 42 percent and 44 percent, respectively, of the total class radar set CASREPs. The greater number of average ship operating years for the CG-26 Class ships may account for this difference. This possibility is examined in Subsection 3.2.1.4.

Comparative Analysis Results

In summary, this comparative analysis subsection has shown the following:

- The CG-26 Class reported a significantly greater number of both ship's force man-hours and IMA man-hours per ship operating year for the radar set and RSPE than either the DDG-37 Class or the FF-1052 Class ships.
- CG-26 Class radar sets were responsible for a significantly greater portion of the individual class Mk 68 GFCS IMA man-hours than the DDG-37 Class and the FF-1052 Class radar sets.
- MDS data revealed a high parts-usage correlation for the three ship classes examined (AN/SPG-53A Radar Set and Mk 1 Mod 1 RSPE).
- Radar Set units 3 and 6 collectively accounted for 62.8 percent to 66.6 percent of the radar set significant part repairs for the three ship classes compared.
- The rates of CASREP submissions against the radar sets were nearly the same for the three ship classes examined.
- CG-26 Class radar set units 3 and 6 were responsible for approximately 55 percent of the total radar set CASREPs, while the DDG-37 Class and the FF-1052 Class radar set units 3 and 6 accounted for approximately 42 percent and 44 percent, respectively, of the total class radar set CASREPs.

The parts-usage and CASREP comparisons indicate that the maintenance experience of the CG-26 Class AN/SPG-53A Radar Sets is very similar to that of the DDG-37 and the FF-1052 Class radar sets. However, the MDS man-hour comparisons indicate that the CG-26 Class maintenance experience might differ from that of the DDG-37 and the FF-1052 Radar Sets. These inconsistencies are examined in Subsections 3.2.1.4 and 3.2.1.5.

3.2.1.3 MDS Data Summary

The available MDS data were examined to determine what percentage of AN/SPG-53A Radar Set and Mk 1 Mod 1 RSPE maintenance has historically been

accomplished by ship's force and to determine the major reasons for unscheduled maintenance. Tables 3-9 through 3-14 summarize the available MDS data. The following facts are taken from those data:

- Approximately 25.8 percent of the radar JCNs and 22.2 percent of the RSPE JCNs were parts-only transactions.
- Approximately 87.4 percent of the radar JCNs with man-hours reported and 83.7 percent of the RSPE JCNs with man-hours reported were completed by ship's force in 10 man-hours or less.
- IMA transactions constituted approximately 1.4 percent of the radar JCNs requiring maintenance and 1.7 percent of the RSPE JCNs requiring maintenance.
- Normal wear and tear was the reported cause of approximately 79.5 percent of the deferred and nondeferred RSPE JCNs.
- Approximately 92.9 percent of the nondeferred radar JCNs and 92.6 percent of the nondeferred RSPE JCNs required supply parts for completion.
- Approximately 76.4 percent of the deferred radar JCNs and 45.5 percent of the deferred RSPE JCNs were generated because of a lack of material (parts).
- Approximately 82.6 percent of the deferred radar JCNs and 77.9 percent of the deferred RSPE JCNs were completed by ship's force.

The major conclusion drawn from these MDS data is that ship's force is capable of accomplishing most radar set and RSPE repairs without outside assistance if the needed parts are available. Conversations with ship's force personnel further substantiated these findings.

3.2.1.4 Ship's Force Maintenance

This subsection examines the ship's force corrective maintenance patterns in order to identify equipment deterioration, the reason for the high average man-hours per ship operating year reported by the CG-26 Class ships, and any periodic unscheduled maintenance actions that are applicable to the entire class.

Maintenance Patterns

To identify those intracycle periods of increased or rising ship's force corrective maintenance (deterioration of equipment), the MDS number of reported ship's force man-hours per quarter after overhaul for each CG-26 Class ship and for the entire class were examined. The number of job initiations (JCNs) per quarter after overhaul and the number of radar set APL parts used per quarter after overhaul were also examined in the same manner. These data did not show any periodic or constant class deterioration of the radar set; but they did show that ship's force maintenance patterns were the result of the ship's schedule rather than the condition of the radar set. For every ship in the class, the amount of maintenance (ship's force man-hours, JCNs, and APL parts used) increased

Table 3-9. MDS SUMMARY FOR AN/SPG-53A RADAR SET (APL 56995306)			
(Total JCNs = 3,266*; Parts-Only Transactions = 841 or 25.8 percent of total JCNs)			
Type of JCN	Man-Hour Distribution		Number of Transactions
	Ship Man-Hours	Percentage of Total JCNs with Man-Hours	
Ship's Force JCNs	0-4	70.3	1694
	5-10	71.1	412
	11-25	7.5	181
IMA JCNs	IMA Man-Hours	Percentage of Total IMA JCNs	
	0-10	51.4	18
	11-20	20.0	7
	21-30	20.0	7
Transactions with Reported Man-Hours		Percentage of Total JCNs	1,083*
		75.8	

*Total number includes transactions that did not require any man-hours or parts.

Table 3-10. MDS SUMMARY FOR AN/SPG-53A RADAR SET (APL 56995306) SUMMARY OF NONDEFERRED JCNs		
(Total JCNs = 3,266*; Parts-Only Transactions = 841 or 25.8 percent of Total JCNs)		
Data Item	Percentage of Total Nondeferred JCNs	Number of Transactions
Reported Cause		
Normal wear and tear	86.7	1448
Unknown	6.8	114
Manufacturer/installation defects	2.4	40
Abnormal environment	1.4	23
When Discovered		
Normal operation	45.3	757
During PMS	18.6	310
During inspection	13.8	230
Lighting Off or starting	12.5	208
Operational Status		
Reduced Capability	39.9	666
Operational	27.8	465
Nonoperational	26.5	442
Action Taken		
Completed with supply parts	92.9	1552
Unknown/other	2.8	46
Completed (no parts used)	1.7	29
Nondeferred JCNs	Percentage of Total JCNs	
	51.1	1670*

*Total number includes transactions that did not require any man-hours or parts.

Table 3-11. MDS SUMMARY FOR AN/SPG-53A RADAR SET (APL 56995306) SUMMARY OF DEFERRED JCNs

(Total JCNs = 3,266*; Parts-Only Transactions = 841 or 25.8 percent of Total JCNs)

Data Item	Percentage of Total Deferred JCNs	Number of Transactions
Reported Cause		
Normal wear and tear	63.4	479
Unknown	25.8	195
Manufacturer/installation defects	4.6	35
Inadequate instruction/procedure	2.5	19
Deferral Reason		
Lack of material	76.4	577
Lack of facilities/capabilities	9.3	70
Unknown	7.8	59
Work backlog/operational priority	5.2	39
Action Taken (Ship's Force)		
Completed with supply parts	67.3	508
Other	6.4	48
Completed (no parts used)	4.8	36
Action Taken (IMA)		
Completed with supply parts	2.4	18
Completed (no parts used)	1.2	9
Type Availability		
Ship's Force	82.6	624
Depot	6.9	52
Unknown	6.5	49
IMA	2.8	21
Deferred JCNs	Percentage of Total JCNs	
	23.1	755

*Total number includes transactions that did not require any man-hours or parts.

Table 3-12. MDS SUMMARY FOR MK 1 MOD 1 RSPE (APL 78640113)

(Total JCNs = 388*; Parts-Only Transactions = 86 or 22.2 percent of Total JCNs)

Type of JCN	Man-Hour Distribution		Number of Transactions
	Ship Man-Hours	Percentage of Total JCNs with Man-Hours	
Ship's Force JCNs	0-4	64.1	193
	5-10	19.6	59
	11-25	8.9	27
IMA JCNs	IMA Man-Hours	Percentage of Total IMA JCNs	
	0-10	40.0	2
	11-20	0.0	0
	21-30	40.0	2
Transactions with Reported Man-Hours		Percentage of Total JCNs	301*
		77.6	

*Total number includes transactions that did not require any man-hours or parts.

Table 3-13. MDS SUMMARY FOR MK 1 MOD 1 RSPE (APL 78640113) SUMMARY OF NONDEFERRED JCNs		
(Total JCNs = 388*; Parts-Only Transactions = 86 or 22.2 percent of Total JCNs)		
Data Item	Percentage of Total Nondeferred JCNs	Number of Transactions
Reported Cause		
Normal wear and tear	87.8	130
Unknown	4.1	6
Manufacturer/installation defects	2.7	4
Abnormal environment	2.0	3
When Discovered		
Normal operation	39.2	58
During PMS	24.3	36
During inspection	11.5	17
Lighting Off or starting	8.1	12
Operational Status		
Reduced Capability	36.5	54
Operational	18.2	27
Nonoperational	41.9	62
Action Taken		
Completed with supply parts	92.6	137
Unknown/other	1.4	2
Completed (no parts used)	3.4	5
Nondeferred JCNs	Percentage of Total JCNs	
	38.1	148*

*Total number includes transactions that did not require any man-hours or parts.

Table 3-14. **MDS SUMMARY FOR MK 1 MOD 1 RSPE (APL 78640113)**
SUMMARY OF DEFERRED JCNs

(Total JCNs = 388*; Parts-Only Transactions = 86 or 22.2 percent of Total JCNs)

Data Item	Percentage of Total Deferred JCNs	Number of Transactions
Reported Cause		
Normal wear and tear	36.4	56
Unknown	52.6	81
Manufacturer/installation defects	1.9	3
Inadequate instruction/procedure	7.1	11
Deferral Reason		
Lack of material	45.5	70
Lack of facilities/capabilities	12.3	19
Unknown	10.4	16
Work backlog/operational priority	30.5	47
Action Taken (Ship's Force)		
Completed with supply parts	30.5	47
Other	18.8	29
Completed (no parts used)	24.7	38
Action Taken (IMA)		
Completed with supply parts	1.9	3
Completed (no parts used)	1.3	2
Type Availability		
Ship's Force	77.9	120
Depot	6.5	11
Unknown	9.7	15
IMA	2.6	4
	Percentage of Total JCNs	
Deferred JCNs	39.7	154

*Total number includes transactions that did not require any man-hours or parts.

before major deployments and before overhauls, and slightly decreased during major deployments from the average maintenance level for individual ships. The differences in the individual ship maintenance levels appear to be caused primarily by nonstandard or sporadic reporting procedures of a given ship.

Manning Levels

The CG-26 Class ships reported a much greater number of radar set corrective maintenance man-hours per ship operating year than the other two classes examined, while the radar set APL parts comparison and CASREP experience comparison indicated that the maintenance experiences of the radar sets were similar (see Subsection 3.2.1.2, Comparative Analysis). A review of MDS narratives, available SARPs, and PMS requirements again did not indicate that the CG-26 Class radar set maintenance experience was different from that of the DDG-37 and FF-1052 Class radar sets.

Conversations with the Manning Control Authority (Navy) personnel indicated that CG-26 Class ships currently have an NMP allowance of 11 Fire Control Technicians, Guns (FTG) and that the DDG-37 Class and the FF-1052 Class ships currently have NMP allowances of nine and seven FTGs, respectively. Although NMP allowances change continually because of Type Commanders' requirements, equipment changes, and rate criticality, it can be assumed that CG-26 Class ships have always had a greater NMP allowance for FTGs than DDG-37 and FF-1052 Class ships. It is also assumed that PMS is always completed and that all critical equipment failures (failures causing CASREP) are repaired as soon as possible on all three ship classes examined. Comparative analysis has shown that the parts replacement histories and the equipment failure experiences for these three ship classes are similar; that is, the same types of repairs are being accomplished. Therefore, it is concluded that the CG-26 Class ships are performing more of the non-critical repairs (needed repairs that would not immediately or would never cause a CASREP if left undone, e.g., minor repairs such as equipment alignments or collimation, or repairs to monitoring or backup equipment) than the DDG-37 and the FF-1052 Class ships because these ships have more personnel. In other words, the greater number of average man-hours per ship operating year reported for the CG-26 Class radar sets does not necessarily indicate a difference in the CG-26 Class radar set maintenance experience. It is therefore concluded that there are no radar set maintenance actions that are unique to the CG-26 Class ships. The CG-26 Class radar set technicians are performing more of the same types of maintenance that are being performed on the DDG-37 Class and the FF-1052 Class ships; hence, CG-26 Class ships are reporting more man-hours per ship operating year than the other classes examined.

3.2.1.5 IMA Maintenance

The MDS narratives for the deferred radar actions requiring outside assistance for completion were examined to identify any maintenance problems that would regularly require an intermediate maintenance activity. The calibration of test equipment and the lack of test equipment were the

only deferred actions reported more than once against the radar. The principal problem associated with the electronic test equipment is not having access to a calibration or repair facility when one is needed.

The calibration and repair of test equipment will be addressed in the recently initiated Metrology Automated System for Uniform Recall and Reporting (MEASURE) Program. This data processing program is designed to provide participating activities with a standardized system for the recall and scheduling of Test, Measurement, and Diagnostic Equipment (TMDE) into calibration facilities, and documentation of the data pertaining to calibration and repair actions performed by these facilities. All of the CG-26 Class ships will have implemented MEASURE before entering DDEOC.

CG-26 Class differences in the IMA maintenance experience could not be verified, because the IMA transactions with reported causes (narratives) other than those mentioned above were few and random in nature.

3.2.1.6 Depot-Level Maintenance

One CG-26 Class ship (CG-30) has been operational for more than five years between overhauls. When the radar set maintenance level (ship's force man-hours reported, JCNs initiated, and APL parts used per-quarter after overhaul) for this ship was examined, it was evident that the amount of radar set maintenance accomplished each year after overhaul did not change significantly over the data period observed; in other words, equipment deterioration was not evident (also see Maintenance Patterns portion of Subsection 3.2.1.4).

A review of the CG-26 Class SARP Summary showed that four of five ship AN/SPG-53A Radar Sets (includes Mk 1 Mod 1 RSPE) have received a Class B overhaul (including exchange of installed scanner assembly), at an average labor expenditure of 253 shipyard man-days and an average cost of $8,340. (CG-30 received a Class B overhaul prior to the MDS data period examined.)

In summary, it can be assured that the AN/SPG-53A Radar Set will operate through the intracycle if a Class B overhaul is accomplished during BOH and subsequent ROHs, the regular PMS is accomplished, and the appropriate corrective maintenance is performed when required.

It is recommended that a Class B overhaul of the AN/SPG-53F Radar Set be accomplished during BOH on all CG-26 Class ships receiving the Mk 68 Mod 16 GFCS during BOH (CG-26, -27, -28, -30, -32, and -33), and that a Class B overhaul of the AN/SPG-53F Radar Set and Mk 1 Mod 1 RSPE (including exchange of the installed antenna with a refurbished unit) be accomplished during BOH on all CG-26 Class ships receiving the Mk 68 Mod 16 GFS during a subsequent ROH (CG-29, -31, and -34). (See Radar Set Background Subsection 3.2.1.1, for recommendation differences.) It is also recommended that all CG-26 Class ship AN/SPG-53F Radar Sets receive a Class B overhaul during each subsequent ROH.

MRC Evaluation

The current applicable maintenance index pages (MIPs) for the AN/SPG-53A Radar Set and the AN/SPG-53F Radar Set were reviewed and compared. Three semiannual PMS requirements were found in the MIPs for the AN/SPG-53F Radar Set that require collimation tower facilities (MIP G-139/5-78). These requirements are shown in Table 3-15. It is therefore recommended that the PMS requirements addressed in Table 3-15 be incorporated in the CG-26 Class CMP as items to be accomplished semiannually in accordance with MRCs S-4R, 5R, and 6R (MIP G-139/5-78).

Review of the MIP for the Mk 1 Mod 1 RSPE did not reveal any requirements for outside assistance. When the RSPE is removed and the solid-state video processor is installed (Mod 16 GFCS), the amount of PMS required will be reduced by approximately 80 man-hours per year. It is also expected that the corrective maintenance burden will be reduced because of the processor's solid-state design and greater accessibility.

Table 3-15. PMS REQUIRING *OUTSIDE* ASSISTANCE (MIPs G-139/5-78)

PMS Requirement	*Periodicity*	Task Description
S-4R	6 months	Test AEI alignment and adjust if necessary. Note: To be accomplished by using collimation tower facilities.
S-5R	6 months	Verify the BEACON operation. Note: To be accomplished by using collimation tower facilities.
S-6R	6 months	Check RADAR-OPTICAL alignment and adjust if necessary. Note: To be accomplished by using collimation tower facilities.

3.2.1.7 Maintainability Improvements

Fleet personnel reported that the new AN/SPG-53F Radar Set, Mk 154 Digital Range Computer (installed by OrdAlt 6894) had an overheating problem. Since a circulating fan and the range computer are completely enclosed, only heated air was being circulated within the unit (Unit 6). Ship's force personnel reported that this problem could be alleviated by operating Unit 6 with the console doors open.

NAVSEA 0432 technical personnel have indicated that this problem is being evaluated. Therefore, it is recommended that the evaluation of extreme temperatures in Unit 6 (Digital Range Computer) be completed and an OrdAlt be designed that will allow cooling air to be circulated over the Mk 154 Digital Range Computer.

3.2.1.8 Recommendations

This section presents both DDEOC and maintenance-policy recommendations resulting from this analysis of the AN/SPG-53A/F Radar Set and the Mk 1 Mod 1 RSPE.

The existing maintenance strategy of performing the preventive maintenance prescribed by PMS and "run to failure" is considered adequate to support the AN/SPG-53F Radar through the extended operating cycle.

The DDEOC recommendations are as follows:

- Baseline Overhaul Requirements
  - Accomplish Class B overhaul of the AN/SPG-53F Radar Set on all CG-26 Class ships receiving the Mk 68 Mod 16 GFCS (CG-26, -27 -28, -30, -32, and -33)
  - Accomplish Class B overhaul of the AN/SPG-53F Radar Set and the Mk 1 Mod 1 RSPE and exchange antennas with refurbished units on all CG-26 Class ships receiving the Mk 68 Mod 16 GFCS during a subsequent ROH (CG-29, -31, and -34). Note: The DDEOC Repair Requirements for BOH (CG-26 Class) dated August 1977 concurs with the basic BOH recommendation to accomplish a Class B overhaul of the AN/SPG-53F Radar Set. However, the repair requirements do not take into account the CG-26 Class BOH configuration differences. It is recommended that the DDEOC Repair Requirements for BOH (CG-26 Class) be adjusted to reflect this difference as stated above.
- Intracycle Maintenance
  - Accomplish the existing PMS requirements for the AN/SPG-53F Radar Set (and the Mk 1 Mod 1 RSPE, when applicable) on all C-26 Class ships.
  - Include an engineered task in the CG-26 Class CMP for ship's force and the depot to test AEI alignment and adjust if necessary every six months in accordance with MRC S-4R, MIP G-139/5-78. Note: Collimation tower facilities will be needed.
  - Include an engineered task in the CG-26 Class CMP for ship's force and the depot to verify BEACON operation every six months in accordance with MRC S-5R, MIP G-139/5-78. Note: Collimation tower facilities will be needed.
  - Include an engineered task in the CG-26 Class CMP for ship's force and the depot to check RADAR-OPTICAL alignment and

adjust if necessary every six months in accordance with MRC S-6R, MIP G-139/5-78. Note: Collimation tower facilities will be needed.

- Follow-On ROH Requirements - Include an engineered task in the CG-26 Class CMP for the depot to accomplish Class B overhaul of the AN/SPG-53F Radar Set.

- Recommended PMS Changes - None.

- Recommended Logistic Support Improvements - None.

- Recommended Reliability and Maintainability Improvements - Complete evaluation of extreme temperatures in Unit 6G and design an OrdAlt that will allow cooling air to be circulated over the Mk 154 Digital Range Computer.

3.2.2 Mk 47 Mod 9 Computer (APL 49402033) and Mk 116 Mod 4 Ballistics Computer (APL 49402034)

3.2.2.1 Background

The Mk 47 Mod 9 Computer is an analog device used to generate gun and fuze-setting orders for 5-inch, 54-caliber gun mounts. Its computations are supplemented by the Mk 116 Mod 4 Ballistics Computer, which either provides gun orders for 3-inch, 50-caliber gun mounts (to be removed during BOH) or provides star shell gun and fuze-setting orders for 5-inch, 54-caliber gun mounts. In this report, the Mk 47 Mod 9 Computer and the Mk 116 Mod 4 Ballistic Computer are discussed as one computer (the Mk 47 Mod 9 Computer) because of their close functional and physical relationship and the similarity of their MDS data. (Most Mk 116 Mod 4 computer data were reported under the APL for the Mk 47 Mod 9 Computer.) Where the available data show that there is a difference in the maintenance experience of the two computers, they are addressed separately.

When the Mk 68 Mod 8 GFCS is modified to a Mk 68 Mod 16 GFCS, these analog computers will be replaced by the digital Mk 160 Mod 1 Gun Computer System (see Table 3-4). This new digital computer system will include an AN/UYK-20(V) Data Processing Set, a Mk 167 Mod 1 Computer Set Control, an RD-358(V)/UYK Digital Magnetic Tape Recorder-Reproducer, and an AN/UGC-79 Teletypewriter Set.

To date, the Mk 160 Gun Computer System has been installed on only two U.S. ships (DDG-2 USS ADAMS (test ship -- no longer installed) and CG-26 USS BELKNAP). Although the cognizant technical codes report that the new digital gun computer system will be easier to maintain and will require fewer corrective maintenance man-hours than the analog (Mk 47 and Mk 116 Computers) system, the lack of sufficient maintenance data for the Mk 160 Gun Computer System prohibits a quantitative analysis. Therefore, no recommendations are made in this subsection for those CG-26 Class ships which will receive the Mk 68 Mod 16 GFCS during BOH (CG-26, -27, -28, -30, -32, and -33).

The following subsections review the maintenance experience for the Mk 47 and Mk 116 computers; appropriate recommendations are made for CG-26 Class ships that will retain the present Mk 68 GFCS configuration until the first ROH after BOH (CG-29, -31, and -34).

3.2.2.2 Comparative Analysis

A comparative analysis was not performed for the CG-26 Class Mk 47 computer because of the basic differences in the Mk 47 Computers among the three ship classes being considered. Table 3-16 summarizes three basic differences for the CG-26, DDG-37, and FF-1052 Class Mk 47 Computers.

Table 3-16. MK 47 COMPUTER DIFFERENCES (CG-26, DDG-37 AND FF-1052 CLASS)

Ship Class	Mk 47 Mod	APL	Type Computer	Solid-State Components Installed	Mk 116 Computer Installed	Mk 155 Computer Installed
DDG-37	7	49400808	Analog	No	Yes	Yes
CG-26	9	49402033	Analog	Yes	Yes	No
FF-1052	10/11	49402526 49402700	Analog	Yes	No	No

As shown in Table 3-16, the Mk 47 Mod 7 Computers do not have solid-state components and have a Mk 155 Ballistics Computer installed. Although the Mk 47 Mods 10/11 Computers are functionally very similar to the Mk 47 Mod 9 Computers, an APL comparison showed that less than 25 percent of the Mk 47 Mod 10/11 parts were common to the Mk 47 Mod 9 Computer. Therefore, comparisons of Mk 47 Computer performance across these three ship classes was deemed inappropriate.

3.2.2.3 MDS Data Summary

Available MDS data were examined for the following purposes:

- To identify the corrective maintenance practices
- To determine the primary reasons for unscheduled maintenance
- To identify the historical participation of the different maintenance activities

Tables 3-17, 3-18, and 3-19 summarize the available Mk 47 Computer MDS data. The following are the highlights of those tables:

- Approximately 82.9 percent of the computer JCNs with reported man-hours were completed by ship's force in 10 man-hours or less.

Table 3-17. MDS SUMMARY FOR THE MK 47 MOD 9 COMPUTER (APLs 49402033 AND 49402034)

(Total JCNs = 1,428*; Parts-Only Transactions = 342 or 23.9 percent of Total JCNs)

Type of JCN	Man-Hour Distribution		Number of Transactions
	Ship Man-Hours	Percentage of Total JCNs with Man-Hours	
Ship's Force JCNs	0-4	68.9	747
	5-10	13.9	151
	11-25	7.9	86
	26-40	2.8	30
	41-50	1.0	11
	51 or more	4.2	45
IMA JCNs	IMA Man-Hours	Percentage of Total IMA JCNs	
	0-5	38.5	5
	16-30	38.5	5
	41 or more	23.0	3
Transactions with Reported Man-Hours		Percentage of Total JCNs	
		75.8	1,083*

*Total number includes transactions that did not require any man-hours or parts.

Table 3-18. MDS SUMMARY FOR THE MK 47 MOD 9 COMPUTER (APLs 49402033 AND 49402034)

(Total JCNs = 1,428*; Parts-Only Transactions = 342 or 23.9 percent of Total JCNs)

Data Item	Percentage of Total Nondeferred JCNs	Number of Transactions
Reported Cause		
Normal Wear and Tear	84.7	587
Unknown	10.5	73
Inadequate Instruction/Procedure	1.9	13
Manufacturer/Installation Defects	1.3	9
When Discovered		
Normal Operation	34.9	242
During PMS	26.8	186
During Inspection	16.9	117
Operation Status		
Reduced Capability	44.6	309
Operational	32.6	226
Non-Operational	15.4	107
Action Taken		
Completed with Supply Parts	86.9	602
Completed (No Parts Used)	7.1	49
Unknown/Other	4.6	32
Nondeferred JCNs	Percentage of Total JCNs	
	48.5	693*

*Total Number includes transactions that did not require any man-hours or parts.

Table 3-19. MDS SUMMARY FOR THE MK 47 MOD 9 COMPUTER (APLs 49402033 AND 49402034) SUMMARY OF DEFERRED JCNs

(Total JCNs - 1,428*; Parts-Only Transactions = 342 or 23.9 percent of Total JCNs)

Data Item	Percentage of Total Nondeferred JCNs	Number of Transactions
Reported Cause		
Normal Wear and Tear	71.1	268
Unknown	20.7	78
Manufacturer/Installation Defects	3.2	12
Deferral Reason		
Lack of Material	64.2	242
Work Backlog/Operational Priority	12.7	48
Unknown	11.1	42
Lack of Facilities/Capabilities	10.1	38
Action Taken (Ship's Force)		
Completed with Supply Parts	64.7	244
Completed (No Parts Used)	3.9	15
Action Taken (IMA)		
Completed with Supply Parts	1.6	6
Completed (No Parts Used)	1.6	6
Type Availability		
Ship's Force	68.4	258
Depot	18.6	70
Unknown	11.4	43
IMA	1.1	4
	Percentage of Total JCNs	
Deferred JCNs	26.4	377*

*Total number includes transactions that did not require any man-hours or parts.

- Approximately 5.2 percent of the JCNs with reported man-hours required 41 or more ship's force man-hours before completion.
- Approximately 1.2 percent of all the transactions with reported man-hours were IMA transactions.
- Normal wear and tear was the reported cause of approximately 79.9 percent of the deferred and nondeferred computer transactions.
- Approximately 86.9 percent of the nondeferred computer JCNs required supply parts for completion.
- Approximately 64.2 percent of the deferred computer JCNs were generated because of lack of material (parts).
- Approximately 68.4 percent of the deferred computer JCNs were completed by ship's force, and approximately 18.6 percent of the deferred computer JCNs were completed by a depot.

It is evident from this MDS data summary that ship's force can accomplish most computer repairs without outside assistance if the needed parts are available, and that very little assistance is required from the IMAs.

3.2.2.4 <u>Deferred Action Review</u>

The MDS narratives that reported IMA man-hours were reviewed to substantiate the findings of the MDS summary, Subsection 3.2.2.2. Ten of the 13 IMA transactions did not identify what work was actually completed by the IMA. All 10 of these IMA transactions originated in FY 1970 or 1971. The three remaining IMA transactions were unrelated and judged to be insignificant because of the relatively small number of combined man-hours reported. Therefore, even though the actual cause of most of the computer IMA transactions is unknown, it appears that the problem or need no longer exists.

Narratives for deferred actions generated because of a lack of facilities or capabilities were also reviewed. The item requested most often was the Class B overhaul to the Mk 47 and the Mk 116 Computers (accomplished by depot). The only other request made by more than one CG-26 Class ship (in this case, four) was to repair the computer patch cables. The narratives indicated that ship's force personnel usually either repaired the cables themselves or purchased new cables.

Ship's force personnel reported that these computer test cables' electrical connectors and guide pins are easily damaged and bent. Since these cables are expensive ($237 to $1,980) and chargeable to the ship's operating funds, the technicians often spend a few hours repairing the cables or simply do without them when they are no longer considered repairable, rather than procure new ones. As a result, some ships do not have a complete allowance of test cables for computer maintenance.

Computer parts considered to be significant in terms of their ratio of replacements to total population and their individual cost (greater than $500) are summarized in Appendix C. This appendix shows that only

one third of the CG-26 Class ships replaced these test cables (Cable Assemblies) during the MDS data period, again probably because of their prohibitive cost.

The lack of these test cables would help explain why some ships report an inordinate number of man-hours to accomplish relatively simple repairs (see Table 3-17, Man-Hour Distribution). The MDS narratives for transactions that required more than 40 man-hours to complete indicated that a great number of those man-hours were spent trying to identify the specific module or part causing the problem. *Proper use of a complete set of test cables could considerably reduce this troubleshooting time.* Therefore, it is recommended that the three CG-26 Class ships (CG-29, -31, and -34) be surveyed and, if necessary, provided a complete set of test cables at no cost to the ship during BOH (AELs 49402284 PA - Computer Mk 116 Mod 4 Accessories, and 49402284SA - Computer Mk Mod Accessories).

3.2.2.5 Parts Usage Review

A review of the significant parts used for the computer indicated that there was no single part or group of parts causing the majority of computer repairs. Not one significant computer part has an average interval between replacements (Total Class Operating Time/Number of Parts Replaced) of less than three years (see Appendix C). Although the majority of the significant parts shown in Appendix C are not carried as on-board spare parts, no part is expected to present a problem during the extended operating cycle. Therefore, no specific parts-related recommendations are made in this subsection.

3.2.2.6 CASREP/MRC Evaluation

The available computer CASREP data (Table 3-20) show that no single part or part classification caused a majority of the reported CASREPs. The type of failure reported most often, approximately 42 percent of the Mk 47 Mod 9 Computer CASREPs, was that gears would either bind or shear. MOTU and NAVSEA technical personnel reported that the primary cause of gear failure is improper or inadequate lubrication. A review of the current PMS requirements for the Mk 47 Mod 9 Computer found that there is one cyclic requirement to clean, inspect, and lubricate the computer. The number of gear-related CASREPs might be reduced if the periodicity of this MRC were increased. (NOTE: a DDEOC cycle is five years versus the standard three years.) Therefore, to increase the equipment availability, it is recommended that MIP G-126/2-48, MRC C-1 be changed to an annual requirement [A-( )].

The review of the applicable MIPs for the Mk 47 Mod 9 Computer and the Mk 116 Mod 4 Computer did not identify any requirements that would necessitate outside assistance.

3.2.2.7 Maintenance Patterns

The computer maintenance level for each CG-26 Class ship and for the entire class was examined by observing the patterns and trends of the

Table 3-20. CASREP SUMMARY FOR MK 47 MOD 9 COMPUTER AND MK 116 MOD 4 COMPUTER		
Component Type	Number of Ships Reported	Number of CASREPs
Computer Mk 47 Mod 9 (APL 49402033)		
Potentiometers	4	6
Gearing	5	11
Timing Motor	3	3
Resolvers	1	1
Synchros	1	1
Power Supply	1	1
Transformers	1	1
Clutches	1	1
Other	1	1
Total		26
Computer Mk 116 Mod 4 (APL 49402034)		
Resolvers	1	2
Amplifiers	2	2
Other	1	1
Total		5
CASREP Data Period = 1/1/72 through 9/1/78 Class Ship Operating Years (SOY) During Data Period = 53.0 Class CASREPs Per SOY = 0.58		

reported MDS ship's force man-hours, job initiations (JCNs) and number of computer APL parts used per quarter after overhaul. The average maintenance level for each CG-26 Class ship varied, but generally the class maintenance level for the computers increased slightly as time out of overhaul increased. This indicates a very slow deterioration of the equipment as a function of time.

One CG-26 Class ship (CG-30) has been operational for more than five years between overhauls. When the computer maintenance level (ship's force man-hours, JCNs, APL parts used) for this ship was examined, it was evident

that the amount of reported computer maintenance did not increase significantly (less than 10 percent increase) over the data period observed. Therefore, the computers will operate through the DDEOC intracycle without significant increase in the required ship's force maintenance if the scheduled PMS is accomplished and corrective maintenance is performed as needed.

The average number of ship's force corrective maintenance man-hours reported per quarter after overhaul was 30.0 man-hours. Since this maintenance level is expected to continue through the DDEOC intracycle, it is recommended that a qualified task be included in the Class Maintenance Plan for ship's force to accomplish the Class C repairs needed to keep the Mk 47 and Mk 116 Computers operational each quarter after overhaul.

3.2.2.8 Depot-Level Maintenance

A review of the available CG-26 Class SARPs showed that four of five ship computers (Mk 47 and Mk 116 Computers) had received a Class B overhaul, requiring an average of 473 shipyard man-days, for an average cost of $29,596 (CG-30 Computer received Class B overhaul).

3.2.2.9 Conclusion

It is concluded that the Mk 47 and Mk 116 Computers are capable of operating through the DDEOC intracycle if a Class B overhaul is accomplished during BOH, the scheduled PMS is accomplished, and the appropriate corrective maintenance is performed when required.

This conclusion is in agreement with the DDEOC Repair Requirements for BOH (CG-26 Class); however, the Repair Requirements should be adjusted to show that this conclusion is applicable only to three CG-26 Class ships (CG-29, -31, and -34) since the Mk 47 and Mk 116 Computers will be removed from the other ships of the class.

3.2.2.10 Recommendations

This subsection presents the DDEOC and maintenance-policy recommendations resulting from the analysis of the Mk 47 Mod 9 Computer and the Mk 116 Mod 4 Computer.

The existing maintenance strategy of performing the preventive maintenance prescribed by PMS and performing the appropriate corrective maintenance when required is adequate to support the Mk 47 and Mk 116 Computers through DDEOC.

The DDEOC recommendations are as follows:

- Baseline Overhaul Requirements - Accomplish Class B overhaul of the Mk 47 Mod 9 Computer and the Mk 116 Mod 4 Computer for CG-29, CG-31, and CG-34.

- Intracycle Maintenance Requirements - Include a qualified CMP task for ship's force to accomplish the Class C repairs required to keep the Mk 47 and Mk 116 Computers operational each quarter after overhaul (CG-29, -31, and -34).
- Follow-On ROH Requirements - None.
- Recommended PMS Changes - Change the periodicity of MIP G-126/2-48, MRC C-1 to an annual requirement (A-( )).
- Recommended Logistic Support Improvements - None.
- Recommended Reliability and Maintainability Improvements - Survey CG-29, CG-31, and CG-34 computer test cables (AELs 49402284PA and 49402284SA) and, if necessary, provide a complete set of test cables at no cost to the ship during BOH.

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the conclusions and recommendations resulting from the Review of Experience for the CG-26 Class Gun Fire Control Systems.

4.1 CONCLUSIONS

The following significant conclusions resulted from this ROE:

- Electronic systems and components do not exhibit any regular failure pattern; that is, the probability of failure is the same at any given time. Therefore, no benefit is derived from periodic replacement of electronic components, and such replacement is not recommended.
- The existing maintenance strategy of performing the preventive maintenance prescribed by PMS and "run to failure" is adequate to support the AN/SPG-53A, F Radar Set and the Mk 47 Mod 9 Computer through an extended operating cycle.
- The Mk 68 Gun Fire Control System equipments installed aboard CG-26 Class ships exhibited maintenance burden patterns similar to those of comparable equipments installed aboard DDG-37 and FF-1052 Class ships.
- Ship's force personnel, with very little outside assistance (IMA or depot), have the capability to perform most major maintenance actions to the AN/SPG-53A/F Radar Set and the Mk 47 Mod 9 Computer.

4.2 RECOMMENDATIONS

Recommendations for corrective action and improvement of Gun Fire Control Systems' equipment maintenance are grouped as follows:

- Baseline Overhaul Requirements
- Intracycle Requirements
- Follow-On Regular Overhaul Requirements
- Reliability and Maintainability Improvements

* PMS Changes
* Integrated Logistics Support Improvements
* Industrial Facility Improvements
* IMA Improvements

Table 4-1 summarizes the recommendations that resulted from the Gun Fire Control Systems' analysis.

Table 4-1. SUMMARY OF ROE RECOMMENDATIONS

Recommendation Number	Component	Recommendation	Report Subsection
Baseline Overhaul Requirements			
1	AN/SPG-53F Radar Set	Perform Class B overhaul of the AN/SPG-53F Radar Set on all CG-26 Class ships receiving the Mk 68 Mod 16 GFCS (CG-26, -27, -28, -30, -32, -33).	3.2.1.6
2	AN/SPG-53F Radar Set and Mk 1 Mod 1 RSPE	Perform Class B overhaul of the AN/SPG-53F Radar Set and the Mk 1 Mod 1 RSPE and exchange antenna with a refurbished unit on all CG-26 Class ships receiving the Mk 68 Mod 16 GFCS during a subsequent ROH (CG-29, -31, -34).	3.2.1.6
3	Mk 47 Mod 9 Computer and Mk 116 Mod 4 Computer	Perform Class B overhaul of the Mk 47 Mod 9 Computer and the Mk 116 Mod 4 Computer for CG-29, -31, and -34.	3.2.2.8
Intracycle Requirements			
4	AN/SPG-53F Radar Set	Accomplish the existing PMS requirements for the AN/SPG-53F Radar Set (and the Mk 1 Mod 1 RSPE, when applicable) on all CG-26 Class ships.	3.2.1.6
5	AN/SPG-53F Radar Set	Test AEI alignment and adjust if necessary every six months in accordance with MRC S-4R, MIP G-139/5-78. NOTE: Collimation tower facilities needed.	3.2.1.6
6	AN/SPG-53F Radar Set	Verify BEACON operation every six months in accordance with MRC S-5R, MIP G-139/5-78. NOTE: Collimation tower facilities needed.	3.2.1.6
7	AN/SPG-53F Radar Set	Check RADAR-OPTICAL alignment and adjust if necessary every six months in accordance with MRC S-6R, MIP G-139/5-78. NOTE: Collimation tower facilities needed.	3.2.1.6
8	Mk 47 Mod 9 Computer and Mk 116 Mod 4 Computer	Perform the Class C repairs required to keep the Mk 47 Mod 9 Computer and the Mk 116 Mod 4 Computer operational (CG-29, -31, and -34).	3.2.2.7
Follow-On ROH Requirements			
9	AN/SPG-53F Radar Set	Perform Class B overhaul of the AN/SPG-53F Radar Set on all CG-26 Class ships.	3.2.1.6
Reliability and Maintainability Improvements			
10	AN/SPG-53F Radar Set	Complete evaluation of extreme temperatures in Unit 6G and design an OrdAlt which will allow cooling air to be circulated over the Mk 154 Digital Range Computer.	3.2.1.7
11	Mk 47 Mod 9 Computer	Survey CG-29, -31, and -34 computer test cables (AELs 49402284 PA and 49402284 SA) and, if necessary, provide a complete set of test cables at no cost to the ship during BOH.	3.2.2.3
PMS Changes			
12	Mk 47 Mod 9 Computer	Change the periodicity of MIP G-126/2-48, MRC C-1 to an annual requirement [A-( )].	3.2.2.6
Integrated Logistics Support Improvements - None			
Industrial Facility Improvements - None			
IMA Improvements - None			

SOURCES OF INFORMATION

The following selected references were used as the basis for the Review of Experience of the Gun Fire Control System.

1. Generation IV MDS narrative and parts usage data for the CG-26 Class ships, 1 January 1970 through 31 December 1977.

2. CASREPs for the CG-26 Class, 1 January 1972 through 31 August 1977.

3. The following technical manuals:

   a) NAVWEPS OP 2649, Volume 1, *Gun Fire Control System Mk 68 Mods 3, 4, 6, and 8, Description and Operation.*

   b) NAVORD OP 2782, Volume 1, *Radar Set AN/SPG-53A, Description, Operation, and Maintenance.*

   c) NAVORD OP 2782, Supplement 2, Volume 1, *Radar Signal Processing Equipment Mk 1 Mod 1, Description, Operation, and Maintenance.*

   d) NAVORD OP 3193, Volume 1, *Computer Mk 47 Mod 9, Description and Operation.*

4. *Ship's Equipment Configuration Accounting System (SECAS) Reports* dated 26 November 1975.

5. Maintenance Index Pages and Maintenance Requirement Cards for the Mk 68 Mod 8, All GFCS and components.

6. *CG-26 Class Repair Profile,* dated October 1975, prepared by PERA (CRUDES).

7. *DDEOC Repair Requirements for BOH, CG-26 Class* dated July 1977.

8. *Mechanized Departure Reports for CG-26 Class Ships,* various dates.

9. ShipAlt briefs and SAMIS data for Mk 68 GFCS alterations, various dates.

10. Trip Report dated 21 May 1979; ARINC Research Corporation visit to USS WAINWRIGHT (CG-28).

11. Navy Management data List (NMDL), dated January 1979.

12. *Type Commander's COSAL/SNSL SURFLANT & SURFPAC*, dated 28 February 1977 and 21 August 1977, respectively.

13. Allowance Parts List (APLs) for selected components of the CG-26 Class Mk 68 Gun Fire Control System.

14. OPNAVINST 4790.4, *Material Maintenance Management (3M) Manual*, Volumes I and II, June 1973.

15. SARPs for CG-26 Class ships (CG-27, -28, -29, -30, -31, -32, and -33).

16. *Index of Alterations to Ordnance (Less Aviation)*, NAVSEA OrdAlt 00, dated 15 October 1978.

17. *Equipment Identification Code (EIC) Master Index, MSOD 4790.E2579*, dated 21 March 1978.

18. *Fleet Modernization Program, Ordnance Improvement Plan (OIP) for Fiscal Year 79*, dated 4 February 1977.

19. *ShipAlt Information Manual, CG-26 Class*, dated September 1978.

20. *System Maintenance Analysis, FF-1052 Class Mk 68 Gun Fire Control System*, ARINC Research Publication 1646-03-4-1585, March 1977.

21. *System Maintenance Analysis, DDG-37 Class Mk 68 Gun Fire Control System*, ARINC Research Publication 1652-03-1807, September 1978.

22. Contact Reports:
    - 5 February 1979 and 6 March 1979, phonecon to NAVSEA 934X.
    - 5 February 1979 and 10 April 1979, phonecon to NAVSEA 04322, Gun Systems Maintenance Section
    - 15 May 1979, Phonecon to the Manning Control Authority, Silver Spring, Maryland.

APPENDIX A

SWAB 481 PICTORIAL BLOCK DIAGRAM

Figure A-1 is a block diagram of the major SWAB 481 (Gun Fire Control System) components showing the main flow of system data among these components and other SWABs.

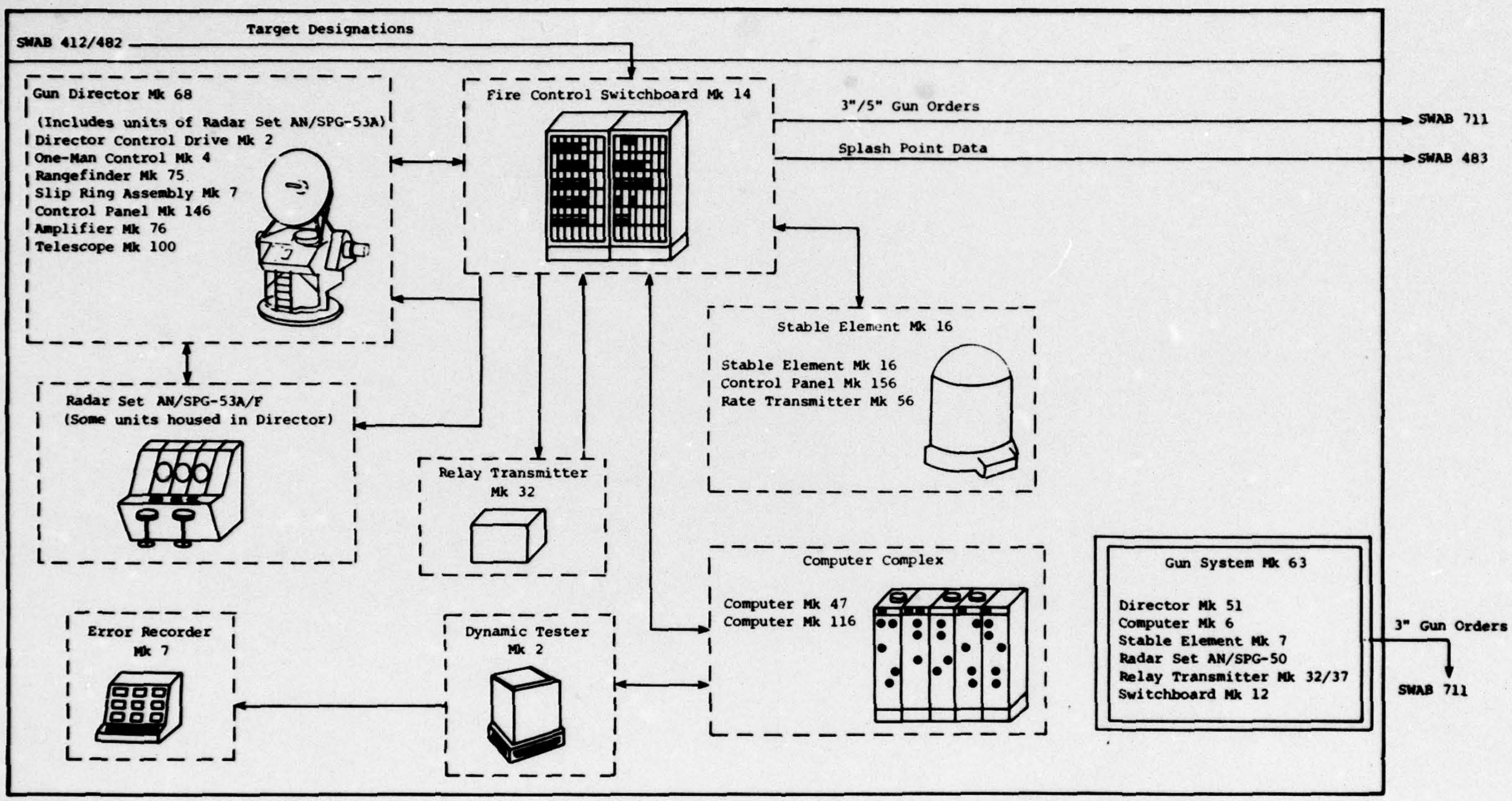

Figure A-1. SWAB 481

APPENDIX B

MDS SUMMARY OF SELECTED SWAB 481 COMPONENTS

This appendix summarizes MDS data for APLs that contributed most significantly to the SWAB 481 maintenance burden. Individual SWAB 481 APLs not shown contributed less than eight Average Man-Hours per Component Operating Year to the total SWAB 481 maintenance burden.

Table B-1. MDS SUMMARY OF SELECTED SWAB 481 COMPONENTS

APL	Nomenclature	Applicable Ships	Components per Ship	Total Component Population	Total Ship Operating Time (Ship-Years)	Ships Reported	JCNs	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Parts Cost (Dollars)	Average Man-Hours/ Component Operating Year
56995306	AN/SPG-53A Radar	9	1	9	60.4	9	3,266	17,450	806	18,256	668,391	302.3
49402033	Mk 47 Mod 9 Computer	9	1	9	60.4	9	1,428	10,549	401	10,950	424,437	181.3
49401956	Mk 68 Mod 3 Gun Director	9	1	9	60.4	9	819	6,048	1,536	7,584	70,852	125.6
49402515	Mk 2 Mod 3 Director Control Drive	9	1	9	60.4	9	428	3,370	216	3,586	70,566	59.4
78640113	Mk 1 Mod 1 R.S.P.E.	9	1	9	60.4	9	388	3,299	95	3,394	28,867	56.2
49402030	Mk 16 Mod 2 Stable Element	9	1	9	60.4	9	279	2,064	30	2,094	124,279	34.7
49401988	Mk 75 Mod 1 Rangefinder	9	1	9	60.4	9	114	993	181	1,174	14,796	19.4
					Totals		6,722	43,773	3,265	47,038	1,402,188	
					Total Reported for all System APLs		7,463	47,967	3,964	51,931	1,540,119	

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APPENDIX C

MDS PARTS USAGE SUMMARY

This appendix summarizes usage data on significant part replacements in the high-burden system components of the Mk 68 Gun Fire Control System. Only those parts considered significant in terms of their ratio of replacements to total part population or their individual cost are presented.

Table C-1. **MDS PARTS USAGE SUMMARY**

Part Identification		Current Cost per Unit (Dollars)	Quantity per Component	Total Part Population	Number Replaced	Ratio (×100) of Parts Replaced to Total Population	Subunit Use	Number of Ships Reported
NSN	Nomenclature							
AN/SPG-53A Radar (APL 56995306)								
9N-5960-00-045-8639	Electron Tube	.71	9	81	125	154.3	3J	8
*9N-5960-00-060-3449	Electron Tube	10.18	6	54	238	440.7	4A/5C	9
9N-5910-00-060-7448	Capacitor, Fixed	15.18	1	9	5	55.5	C(3B4)1	4
*9N-5960-00-082-4139	Electron Tube	.98	7	63	83	131.7	9A/6E	8
9N-5905-00-100-2869	Resistor	5.40	2	18	19	105.5	5C	5
1H-5960-00-102-1516	Magnetron	2210.00	1	9	18	200.0	V(3B1)1	6
9N-5960-00-134-5994	Electron Tube	1.98	14	126	177	140.5	6A/6G	9
*9N-5960-00-134-6031	Electron Tube	1.26	9	81	276	340.7	3J/6D/6F	9
9N-5960-00-134-6064	Electron Tube	1.74	1	9	14	155.6	V(6A1)5	6
*9N-5960-00-134-6073	Electron Tube	1.18	1	9	78	866.7	V(3F)2	9
*9N-5960-00-170-4582	Electron Tube	44.63	2	18	29	161.1	6D/6E	9
9N-5960-00-179-4749	Electron Tube	1.05	4	36	114	316.7	6F/6G	8
9N-5960-00-179-4749	Electron Tube	2.54	9	81	92	113.6	6A/6F	9
*9N-5960-00-188-6605	Electron Tube	10.57	7	63	101	160.3	4B/4D	9
*9N-5960-00-188-8565	Electron Tube	4.76	3	27	106	392.6	6F	8
9N-5960-00-193-5085	Electron Tube	5.71	6	54	48	88.9	4A/4B/4C	9
9N-5945-00-233-5666	Relay, Armature	64.63	1	9	7	77.8	K(5A)1	3
9N-5960-00-261-8649	Electron Tube	104.64	2	18	26	144.4	6C/6D	7
9N-5960-00-262-0161	Electron Tube	3.55	10	90	87	96.7	4C	9
*9N-5960-00-262-0210	Electron Tube	1.05	27	243	403	165.8	6B/6C/6D/9A	9
9N-5960-00-262-0260	Electron Tube	10.98	1	9	38	422.2	4A	7
*4N-5840-00-265-6568	Amplifier, I.F.	429.00	1	9	14	155.6	6F	7
9N-5960-00-272-9182	Electron Tube	.81	1	9	18	200.0	V(9C)3	7
9N-5905-00-279-1933	Resistor, Fixed	.12	2	18	70	388.9	6F	7
9N-5960-00-284-5823	Electron Tube	12.82	20	180	328	182.2	4A/4B/4C/4D	9
*9N-5960-00-296-0059	Electron Tube	220.56	1	9	212	2355.6	V(3F)1	9
9N-5960-00-296-3365	Electron Tube	267.75	1	9	16	177.8	V(6B)1	7
1H-5961-00-469-5160	Rectifier	100.00	2	18	15	83.3	3B	8
4N-1285-00-487-3084	Mixer Stage	1220.00	1	9	2	22.2	(3G)	2
9N-5985-00-538-7329	Dummy Load, Elec.	242.10			5			5
9N-5960-00-542-7004	Electron Tube	2.52	13	117	127	108.5	6A	9
*9N-5960-00-552-0082	Electron Tube	1.51	2	18	117	650.0	V(3B2)1/2	8
*9N-5960-00-569-9533	Electron Tube	50.68	1	9	41	455.6	6F	9
9N-5960-00-578-1652	Electron Tube	65.66	4	36	44	122.2	6B/6G	8
*2J-1285-00-593-6976	Antenna, Radar	6960.00	1	9	52	577.8	1A	9
*9N-5960-00-615-4309	Semiconductor Device	1.18	3	27	253	937.0	3G	9
9N-5910-00-617-4041	Capacitor, Fixed	1.85	1	9	26	288.9	C(6A)32	5
9N-5960-00-617-6097	Electron Tube	1.92	26	234	316	135.0	4B/4C	9
*9N-5945-00-644-7115	Relay, Motor Driven	141.57	1	9	9	100.0	K(5D)1	5
9N-5960-00-669-6858	Semiconductor Device	2.83	2	18	21	116.7	6F/6G	6
*4N-5840-00-705-1678	Board, Printed Circuit	592.00	1	9	74	822.2	(3H)	9
1N-3010-00-705-1681	Clutch, Magnetic	232.11	1	9	7	77.8	CL(6G1)1	4
1H-5915-00-705-1701	Network	68.00	1	9	11	122.2	Z(6F2)2	6
9N-5915-00-705-1702	Network	286.21	1	9	11	122.2	Z(6F2)1	7
4N-5845-00-705-1704	Gear Unit	9050.00	1	9	3	33.3	(6G1)	3
9N-5985-00-705-2911	Waveguide	35.39	1	9	11	122.2	3B	8
9N-5910-00-705-4843	Network	560.12	1	9	11	122.2	C(6G1)1	5
9C-3040-00-705-9387	Shaft, Drive	62.65	1	9	9	100.0	MP(3B)1	6
9N-5905-00-722-3168	Resistor, Variable	66.68	1	9	18	200.0	R(6G1)1	8
9N-5905-00-722-3546	Transformer	209.28	1	9	7	77.8	T(3B)1	4
*9N-5960-00-724-7319	Electron Tube	28.00	1	9	34	377.8	V(6F)1	9
*4N-5840-00-726-0507	Amplifier, I.F.	766.00	1	9	16	177.8	(3J)	6
9N-5930-00-765-6600	Switch, Airflow	10.17	1	9	12	133.3	3P	8
*9N-5960-00-800-3537	Electron Tube	208.25	1	9	61	677.8	TR(3E)1	9
*9N-5960-00-804-9034	Electron Tube	6.07	2	18	293	1627.8	V(5B)1/2	9
*9N-5960-00-808-6977	Electron Tube	38.37	1	9	48	533.3	V(5C)5	9
1H-5985-00-836-2974	Coupler, Directional	956.00	1	9	1	11.1	(3D)	1
*9N-5960-00-836-6504	Electron Tube	115.92	1	9	72	800.0	V(3B)1	9
1H-5915-00-856-9248	Network	933.00	1	9	1	11.1	Unknown	1
*1H-5840-00-867-5526	Horn, Waveguide	224.00	1	9	16	177.8	E(1A)1	9
*9N-5960-00-879-5078	Electron Tube	.80	13	117	183	156.4	5A/5B/6F	9
9N-5960-00-892-0861	Magnetron	922.00	1	9	108	1200.0	V(3B)2	9
9N-5910-00-899-7895	Capacitor	7.28	2	18	15	83.3	3B	4
9N-5945-00-911-9891	Relay	296.47	1	9	6	66.7	5A/5D	5
4N-5840-00-929-8819	Rng. Rate Gear Unit	12130.00	1	9	5	55.6	(6G1)	3
1H-5905-00-929-8819	Resistor	6.60	1	9	14	155.6	R(3B)13	7
1H-5915-00-929-8823	Network, P.F.	485.00	1	9	5	55.6	Z(3B1)1	5
*9N-5961-00-958-9682	Semiconductor Device	3.52	2	18	215	1194.4	3G/3F	9
1H-5950-00-980-2256	Transformer, Pulse	531.00	1	9	11	122.2	T(3B1)1	5
9N-5961-00-985-4900	Semiconductor Device	.14	2	18	12	66.7	6G	4

*Significant Parts identified in both the DDG-37 Class and the FF-1052 Class Mk 68 GFCS SMAs.

Table C-1. (continued)

Part Identification		Current Cost per Unit (Dollars)	Quantity per Component	Total Part Population	Number Replaced	Ratio (×100) of Parts Replaced to Total Population	Number of JCNs Reported	Number of Ships Reported
NSN	Nomenclature							
Mk 1 Mod 1 Radar Signal Processing Equipment (APL 78640113)								
*9N-5960-00-179-4446	Electron Tube	1.05	7	63	55	87.3	11	7
9N-5960-00-179-4749	Electron Tube	2.54	1	9	10	111.1	4	3
*4N-5840-00-916-8613	Video Processor Assy.	955.00	1	9	2	22.2	2	2
*4N-5840-00-916-8804	ACQ & Track	2550.00	1	9	4	44.4	4	2
*4N-5840-00-916-8805	Acquisition Control	3330.00	1	9	1	11.1	1	1
*4N-5840-00-916-8938	Detector Assy.	1120.00	1	9	1	11.1	1	1
*4N-5840-00-916-8940	Amplifier, I.F.	547.00	1	9	4	44.4	4	3
9N-5945-00-979-8205	Relay, Armature	65.66	1	9	7	77.8	6	3
*4N-1285-00-993-6425	Amplifier, I.F.	2610.00	1	9	4	44.4	4	3
Mk 47 Mod 9 Computer (APLs 49402033, 49402034)								
*9N-5905-00-556-4636	Resistor	132.34	1	9	9	100.0	9	6
*4N-1220-00-573-9042	Integrator	1150.00	3	27	8	29.6	5	4
*9N-5905-00-578-3378	Resistor	123.10	1	9	19	211.1	19	9
9G-6680-00-578-5933	Generator, Tach.	656.43	1	9	4	44.4	4	3
9C-3010-00-578-8381	Gearcase - Motor	616.22	1	9	4	44.4	4	4
*9N-5905-00-593-8226	Resistor	242.10	1	9	9	100.0	8	4
*9N-5905-00-593-8227	Resistor	229.79	1	9	13	144.4	12	5
9N-5905-00-593-8253	Resistor	278.01	1	9	4	44.4	4	3
1H-1220-00-614-8029	Network Box	202.00	1	9	5	55.6	5	3
*1H-1220-00-730-7856	Cable Assembly	1050.00	1	9	3	33.3	3	3
*1H-1220-00-730-7857	Cable Assembly	1980.00	1	9	2	22.2	2	2
*1H-1220-00-730-7859	Cable Assembly	327.00	1	9	3	33.3	3	3
*1H-1220-00-730-7861	Cable Assembly	756.00	1	9	3	33.3	3	3
4N-5990-00-761-9160	Resolver	704.00	10	90	6	6.7	6	3
4N-5990-00-961-6028	Resolver	916.00	8	72	19	26.4	18	7
*9N-5905-00-988-1205	Resolver	164.14	1	9	10	111.1	8	4
9N-5905-00-988-1225	Resistor	99.51	2	18	9	50.0	6	4

*Significant parts identified by DDG-37 Class Mk 68 GFCS SMA.